Department of the Interior
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LANDSAT 7 (L7) ENHANCED THEMATIC MAPPER PLUS (ETM+) LEVEL 1 GEOMETRICALLY CORRECTED (L1G) DATA VALIDATION PLAN

Version 1.0

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Executive Summary

This Landsat 7 (L7) Level 1 Geometrically Corrected (L1G) Data Validation Plan provides the U.S. Geological Survey (USGS) and the Landsat International Cooperators (ICs) with a reference document to support the validation of L7 Enhanced Thematic Mapper Plus (ETM+) Level 1G (L1G) systematically corrected data products generated by the ICs or their component International Ground Stations (IGSs).

This document provides the standard data format, processing, and delivery requirements for all L1G product files generated by IC/IGS systems and submitted for validation by the USGS L1G validation systems. This document also describes the methodology and evaluation criteria that the USGS Landsat Project uses to support the L1G IC/IGS validation activity, and details the radiometric and geometric standards and failure thresholds as previously established and agreed upon by the Landsat Technical Working Group (LTWG) in support of L1G product validation activities.

The Landsat Configuration Control Board (LCCB), on behalf of the LTWG, maintains and controls this document. This document may be updated or revised only upon LCCB approval. Please direct any comments and questions regarding this document to the following:

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Document Change Summary

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LS-IC-11	Version 1.0	April 2008	CCR 5170, LCCR 374

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Section 1 Introduction

1.1 Purpose and Scope

The purpose of this Landsat 7 (L7) Level 1 Geometrically Corrected (L1G) Data Validation Plan is to define the implementation, procedures, and criteria used to validate the quality of L7 Enhanced Thematic Mapper Plus (ETM+) L1G systematically corrected data products generated by the Landsat International Cooperators (ICs) and/or their component International Ground Stations (IGSs).

This document defines the overall implementation strategy for the optional annual L1G validation activity and specifies the standard data format, processing, and delivery requirements for any L1G data validation product submitted by the ICs or IGSs for validation by the USGS L1G validation systems. This document further describes the validation methodology and evaluation criteria that the USGS uses to evaluate the IC/IGS L1G data product(s), and details the radiometric and geometric standards and failure thresholds as previously established and agreed upon by the Landsat Technical Working Group (LTWG).

This document does not address the implementation, procedures, and criteria used for the mandatory biannual validation of Raw Computer Compatible (RCC) or Level Zero Reformatted Distribution Product (L0Rp) IC data. This document also does not describe the conditions and procedures used to implement the Data Exchange Annex of the Memorandum of Understanding (MOU) between the U.S. Geological Survey (USGS) and the International Cooperator (IC). The Landsat 7 (L7) Enhanced Thematic Mapper Plus (ETM+) Data Validation and Exchange Implementation Plan (LS-IC-05) addresses these topics separately.

1.2 Intended Users

This L1G data validation plan is primarily intended to be a guide for IC/IGS producers of L7 ETM+ L1G products who are seeking to have their processing system outputs validated by the USGS. This document contains detailed information on the L1G output data file specifications and preferred packaging of L1G data submissions. It also contains information on the evaluation methodology that the USGS uses to compare IC-generated products with the corresponding USGS-generated product, in order to verify L1G product interchangeability. This information may provide a useful reference for the IC or IGS representative when interpreting the USGS-generated L1G data validation reports.

1.3 Overview and Background

Bilateral data quality validation and exchange is generally established under the provisions of the L7 MOU that exists between the USGS and each of the ICs. While the IC represents the signatory organization, each IC may operate one or more individual IGSs. The IGS is generally the entity that is responsible for receiving direct X-band downlink data from the L7 satellite and interacting with the USGS for the data validation activities.

The primary mechanism for IGS data validation, as established by the L7 MOU, exists as an ongoing mandatory biannual program of RCC and/or L0Rp validation of L7 products generated by the USGS and its ICs. The purpose of this activity is to ensure full archive compatibility and ground station interoperability, in case station-to-station data exchange is ever required. The Landsat 7 (L7) Enhanced Thematic Mapper Plus (ETM+) Data Validation and Exchange (DV&E) Implementation Plan (LS-IC-05) fully describes this mandatory RCC and L0Rp activity.

The L1G validation activity described in this document exists as a supplemental L1G validation opportunity that is available to any Landsat IC and/or member IGS. Participation in this optional activity is not specifically required or provided under the L7 MOU. Rather, the implementation details for this activity were established through an LTWG Validation Subgroup initiative that was formed by member stations who had interest in establishing and maintaining a common set of data quality standards that could be used to assure comparable and consistent product quality for Level 1G Landsat 7 products generated by member stations.

The L1G product validation activity consists of a detailed comparison between a USGS-generated L1G data product and the equivalent L1G product generated by an external IC/IGS processing system. This L1G product comparison includes: (1) verifying compliance of the IC data with the current L7 ETM+ Level 1 Data Format Control Book (DFCB) (LS-DFCB-04) for the specified L1G validation format (Fast-L7A); and (2) performing several analytical tests used to compare and verify the radiometric and geometric qualities of the USGS- versus IC-generated L1G data products.

Section 2 of this document outlines the L1G validation implementation plan, and details the particular processing, format, media, and product delivery requirements that all stations that opt to participate in the L1G validation activity must follow. Section 3 provides the methodology that the USGS currently uses to validate IC/IGS L1G products. Section 4 specifies the error thresholds that are currently in effect for each of the USGS vs. IC/IGS L1G product quality comparisons.

Section 2 L1G Validation Product Requirements

2.1 Validation Data Requests

Each IC-operated IGS is offered one opportunity annually to provide the USGS a pair of L1G product samples for L1G validation purposes. For each station, this L1G validation opportunity is generally offered along with one of the mandatory biannual RCC and/or L0Rp validation product requests. However, this L1G validation opportunity is not required. The L1G validation request is optional and not required by the L7 MOU.

Each IGS establishes and maintains a single Point-Of-Contact (POC) who serves as the primary interface for all communications with the USGS POC regarding Level 1 data validation activities and results. Ideally, this POC would be the same person who also serves as the IGS primary interface for all RCC and/or L0Rp data validation activities.

The USGS selects all scenes used for L1G validation exercises. After scene selection, the USGS POC sends a data request to the IGS POC. Within this request, the USGS POC specifies the path, row, and acquisition date of the scene selected, along with any particular processing parameters required to perform a successful analysis.

2.2 Format Requirements

All IC/IGS L1G validation data submissions are to be delivered as a full Worldwide Reference System-2 (WRS-2) single-scene product in Fast-L7A format, generated in accordance with the L7 ETM+ Level 1 DFCB (LS-DFCB-04).

The Fast-L7A (FL7A) output product must include the following components, with all file names in compliance with the L7 ETM+ Level 1 DFCB (Section 2.1; LS-DFCB-04):

- Nine image files in FL7A format (Section 3.1.1 of the L7 ETM+ Level 1 DFCB, LS-DFCB-04, describes the image format)
- Three header files in FL7A format (one for each band group; Section 3.1.2 of the L7 ETM+ Level 1 DFCB, LS-DFCB-04, describes the header format)
- One Level 1 product metadata file (one for each product; Section 3.1.3 of the L7 ETM+ Level 1 DFCB, LS-DFCB-04, describes the metadata format)

Note: The Fast-L7A and other file formats described within the L7 ETM+ Level 1 DFCB (LS-DFCB-04) specification are applicable to all L7 ETM+ output products generated by USGS L1G processing systems, including the Level 1 Product Generation System (LPGS) and the National Land Archive Processing System (NLAPS). The FAST-L7A format is a variant of the heritage FAST-C format, after modification to accommodate sensor-specific features of the ETM+ instrument.

The Fast-L7A format is the standard format of the LTWG Working Subgroup for all L1G validation purposes. Proper header file and metadata formatting are also essential for the success of a number of different analytical tools used for the L1G product validation steps.

2.3 Processing Requirements

All IC/IGS L1G validation products must be generated using a very specific set of processing parameters. A number of these processing parameters are essential for the success of USGS algorithms and tools used to perform the product comparison. Using these processing parameters in the submitted validation product is also required to allow a standardized interpretation of the L1G validation results and uniform application of any relevant error thresholds.

Table 2-1. L1G Validation Product Processing Requirements

specifies the L1G validation product processing requirements.

Processing Requirements		Notes
Level of Processing	Systematic (Level 1G)	Radiometrically and geometrically corrected; no ground control or terrain model used.
Ephemeris Source	Definitive	No Predictive ephemeris.
Product Orientation	MAP orientation (north up)	No nominal ("NOM"), path, or satellite ("SAT") orientation.
Resampling Method	CC (cubic convolution) NN (nearest neighbor)	**Two** products are required for L1G validation: one CC-resampled product (for geometric comparison) and one NN-resampled product (for radiometric comparison). For the CC product, use parametric cubic convolution with alpha = -0.5
Map Projection	UTM	Universal Transverse Mercator
Datum	WGS84	World Geodetic System of 1984
Pixel Size Options	15m / 30m / 60m *-or-* 14.25m / 28.5m / 57m *-or-* 12.5m / 25m / 50m	Pixel sizes must always be selected so that the panchromatic band pixels are less than or equal to 15 meters, the reflective band pixels are less than or equal to 30 meters, and the thermal band pixels are less than or equal to 60 meters. Additionally, the values for the panchromatic, reflective, and thermal bands must be integer multiples of one other and the thermal band must also be double the value of reflective bands.

Table 2-1. L1G Validation Product Processing Requirements

If an IGS cannot provide an L1G product using all of the processing criteria detailed in

Table 2-1. L1G Validation Product Processing Requirements

, the IGS should contact the USGS POC **prior to product delivery.** The USGS POC then determines if an alternative processing parameter can be used for the L1G validation exercise.

Note: To perform a complete radiometric and geometric validation, two versions of the product must always be provided:

- Validation product #1 using Cubic Convolution (CC) resampling (used for geometric comparison)
- Validation product #2 using Nearest Neighbor (NN) resampling (used for radiometric comparison)

2.4 Media Requirements

All L1G validation data submissions must be delivered as a single full WRS-2 scene product in FAST-L7A format, written to electronic or hard media in accordance with the L7 ETM+ Level 1 DFCB (Section 4; LS-DFCB-04).

In most cases, physical media are preferred. If electronic transfer will be used, the USGS may request that the data be provided via File Transfer Protocol (FTP) push from the IGS to a specified USGS FTP location.

2.5 Supplementary Information

Hard copy or hand-written documentation of the data contents is required for all physical media transferred to and from the USGS. Soft copy documentation of the data contents is required for all electronic media transferred to and from the USGS.

The specific information required for all L1G validation data submissions include the following:

- Path
- Row
- Acquisition date
- Ground station ID
- Processing date
- Processing system/version
- Resampling method

2.6 Data Delivery & Turnaround

To ensure a timely completion of the validation procedures, a two-week turnaround time is required from the receipt of the validation data request at the IGS to the delivery of the L1G data products at the USGS. The IGS is responsible for placing orders and addressing any logistical issues related to fulfilling the USGS data request.

2.7 Documentation of Validation Results

The USGS documents the detailed results of the L7 data quality validation to the IGS POC after completing each validation exercise. Level 1G validation results are also reported on a yearly basis to the Landsat Technical Working Group (LTWG) and Landsat Ground Station Operations Working Group (LGSOWG) participants.

2.8 Scheduling and Frequency

Each IGS has an opportunity to provide L1G validation data to the USGS once per year. Similarly, an IGS may request one L1G validation sample data set (i.e. "reciprocal data") from the USGS once per year. Additional data sets may be provided upon IC request and approval of the Landsat Project Manager.

2.9 Data Policy

Any data exchanged for validation purposes, either to or from an IC, may be redistributed in accordance with the existing Landsat data distribution policy.

2.10 Data Validation by the IGS

Each IGS may receive one single-scene L1G validation sample data set from the USGS once per year. Additional validation data sets may also be provided to the IGS upon request and approval of the Landsat Project Manager.

When USGS data are provided to an IGS for data validation purposes, the IGS is requested to provide a detailed summary of the data validation results to the USGS within 60 days after IGS receipt of the data.

Each IGS is responsible for creating and maintaining its own methodology for the IGS L1G validation exercise(s). The IGS validation methodology may or may not be the same as any product comparison methods used by the USGS.

Section 3 L1G Validation Methodology

The L1G product validation process generally consists of comparing a pair of L1G products generated by the IC/IGS systems to a corresponding pair of reference products generated by the USGS systems. This L1G validation includes detailed product comparisons with respect to a number of different format and data quality characteristics, including: header file and metadata consistency, scene framing consistency, geometric consistency, and radiometric consistency. The product comparison also involves checking various aspects of the delivered IC/IGS L1G data product for compliance with relevant sections of the most current version of the L7 ETM+ Level 1 DFCB (LS-DFCB-04).

The following sections define the methodology that the USGS uses for each of these comparisons, as well as the specific criteria used to generate a “PASS/FAIL” determination for each comparison.

3.1 Fast-L7A Format and File Names

Each L1G validation product must be delivered in Fast-L7A format, as described in the L7 ETM+ Level 1 DFCB (Sections 2.1 and 3.1; LS-DFCB-04).

All Fast-L7A file names must be present and named in accordance with the Level 1 ETM+ DFCB (Section 2.1; LS-DFCB-04).

This is verified by visual and/or automated inspection of the Fast-L7A product and component files delivered with the product. Correct file naming and packaging is also verified indirectly by the successful ingest, interpretation, and/or conversion of the scene data via numerous software packages used throughout the validation process.

The criteria for “PASS” include the following: a product is delivered in Fast-L7A format, all expected files are present, and all files are named in accordance with the DFCB.

3.2 Header Files

Each L1G validation product must include the following three Fast-L7A header files:

- Panchromatic Band Header File (HPN) – corresponding to Band 8
- Reflective Band Header File (HRF) – corresponding to Bands 1-5, 7
- Thermal Band Header File (HTM) – corresponding to Bands 6L, 6H

The format and content of the header files must conform to the Fast-L7A header file format described in the L7 ETM+ Level 1 DFCB (Section 3.1.2; LS-DFCB-04), and all fields should be populated correctly.

This is verified directly by visual and/or automated inspection of all three Fast-L7A header files. To facilitate finding anomalies, software may be used to compare and find differences in the IGS and corresponding USGS files. Correct header file format and

content is also verified indirectly by the successful ingest, interpretation, and/or conversion of the scene data via numerous software packages used throughout the validation process.

The criteria for “PASS” include the following: the Fast-L7A header file formats are in full compliance with the L7 ETM+ Level 1 DFCB (Section 3.1.2; LS-DFCB-04), and all fields appear to be correctly populated.

3.3 Metadata File

Each L1G validation product must include a full L1G product metadata (.MTL) file.

The format and content of the metadata file must conform to the Level 1 Metadata File format described in the L7 ETM+ Level 1 DFCB (Section 3.1.3; LS-DFCB-04), and all fields should be populated correctly.

This is verified directly by visual and/or automated inspection of the metadata file. To facilitate finding anomalies, software may be used to compare and find differences in the IGS and corresponding USGS files. Correct metadata format and content is also verified indirectly by the successful ingest, interpretation, and/or conversion of the scene data via numerous software packages used throughout the validation process.

The criteria for “PASS” include the following: the metadata file format is in full compliance with the L7 ETM+ Level 1 DFCB (Section 3.1.3; LS-DFCB-04), and all fields appear to be correctly populated.

3.4 Geometric Comparison

3.4.1 Absolute and Relative Geodetic Accuracy

Validation of the absolute and relative geodetic accuracy is performed by comparing the IC/IGS product Band 8 (CC-resampled version) to the USGS product Band 8 (CC-resampled version).

This uses an automated image-to-image (“i2i”) comparison routine within the Image Assessment System (IAS). Because the radiometric differences between these two products should be very small (or at least linear), this validation method based on cross-correlation is considered suitable.

Within the IAS routine, features suitable for cross-correlation assessments are first selected within the USGS product (Band 8) used as reference. 100 feature points in a 10x10 grid are selected throughout the image. Small (32x32 pixels) image chips are then extracted around the features. The normalized cross-correlation function is computed over a search window around the predicted position in the IGS product Band 8. The subpixel position for the corresponding point in the IC/IGS product is located at the (interpolated) maximum of the cross-correlation function. The ground coordinate Universal Transverse Mercator (UTM) is then calculated for the point positions in both the USGS and the IC/IGS image. Their deviations are calculated by subtracting the IGS point coordinate from the

USGS point coordinate. The Root Mean Square Error (RMSE) and Standard Deviation (STDV) are calculated using all point deviations for line and sample directions, respectively. The resulting RMSE and STDV are then compared to the respective threshold. For full details on the algorithms and calculations the IAS uses during the image-to-image comparison, please refer to Section 3.1.5.5.2 of the L7 IAS Geometric Algorithm Theoretical Basis Document (ATBD) (LS-IAS-01).

The IGS-to-USGS absolute geometric error is represented as T-GEOM-ABS, which is the RMSE difference in the line and sample components between the IGS product band and the corresponding USGS product band.

The IGS-to-USGS relative geometric error is represented as T-GEOM-REL, which is the STDV of the difference in the line and sample components between the IGS product band and the corresponding USGS product band.

The criteria for “PASS” include the following:

RMSE-line <= T-GEOM-ABS
RMSE-sample <= T-GEOM-ABS
STDV-line <= T-GEOM-REL
STDV-sample <= T-GEOM-REL

3.4.2 Band Registration Accuracy

Band registration accuracy is validated by performing a band-to-band (“b2b”) alignment analysis upon the IGS product (CC-resampled). If any band comparisons exceed the established error thresholds within the IGS product, then a second band-to-band alignment analysis is performed on the USGS product (CC-resampled), and the results are compared.

The band registration accuracy determination uses an automated band-to-band analysis routine within the IAS. Within this routine, one band (e.g., Band 3) is selected as the reference band. 100 points in a 10 by 10 grid are selected as in the geodetic accuracy assessment, and their corresponding positions are to be found in the remaining bands. These points may or may not be identical to the points used for i2i comparison, depending on relative differences in the comparison scenes. For the preferred scenes in arid areas, the correlation between bands may be high enough to make cross-correlation successful; however, there may be cases where this will fail due to lack of correlation between two given bands. This is common in band-to-band comparisons involving the thermal infrared bands (6L/6H) or Band 4. Comparisons between bands of differing resolutions (i.e., the panchromatic and thermal bands) are performed by artificially reducing the resolution of the higher resolution band using an image pyramid technique **(Park and Schowengerdt, 1983).**

For all band-to-band comparisons, the ground coordinate (UTM) is calculated in both bands, and their deviations are calculated by subtraction. The RMSE deviation is then calculated using all point deviations for line and sample directions, respectively. The

RMSE deviation is then compared to their respective threshold after division by the pixel size in the band with the larger pixels. For full details on the algorithms and calculations that the IAS uses during the band-to-band comparison, please refer to Section 3.1.5.5.1 of the L7 IAS Geometric Algorithm Theoretical Basis Document (ATBD) (LS-IAS-01).

The band-to-band geometric error is represented as T-GEOM-BAND, which is the RMSE difference (in the line and sample components) between one of the product bands and any of the other bands in the same product. The pixel size to be used in the threshold is the larger of the two bands in the comparison. For products resampled to pixel sizes other than the standard 30-meter (multispectral), 15-meter (panchromatic), and 60-meter (thermal), the registration results will be scaled to these nominal pixel sizes:

RMSE-line <= T-GEOM-BAND
RMSE-sample <= T-GEOM-BAND

The criteria for “PASS” (for either the IGS or USGS product) include the following:

RMSE-line <= T-GEOM-BAND
RMSE-sample <= T-GEOM-BAND

Note: The IGS product will fail band-to-band analysis for any particular band only after comparison against USGS band-to-band results for the same scene. Band-to-band failure only occurs after confirmation that the IGS product exceeds the failure threshold while the USGS product does **not** exceed the failure threshold.

3.5 Scene Framing Comparison

Scene framing is validated by comparing the active image area (scene frame) for Band 8 of the IGS versus the USGS product. The IGS scene is required to cover the USGS frame to a specified minimum extent.

Initially, the hypothesis that the IGS scene completely covers the along-track extent of the USGS scene may be verified by visual inspection. If the IGS scene cover is complete, no measurements need to be made. If there is only a partial cover, the extent of cover shortage must be measured. First, at the top border in an IGS scene (if not covering the USGS top border), a point must be found that can also be identified in the USGS scene. Then the along-track distance (LT) to the top border in the USGS scene and the distance (LB) to bottom border (if not covered) must be measured.

The scene framing error is represented as T-FRAME, which is the maximum along-track distance in which the IGS product does not overlap in the corresponding USGS product.

The criteria for “PASS” include the following:

LT+LB <= T-FRAME

3.6 Radiometric Comparison

Radiometric validation is performed by comparing bulk statistics based on radiance values for each band, generated for both the IGS (NN-resampled) and USGS scene (NN-resampled). The at-aperture radiance calculated in the IGS product should be consistent with the USGS product.

For both products, the data are spatially subset to include a common active image area, and the subset images are then transformed to bulk (full-image) radiance units using calibration factors obtained from the metadata files. The statistical mean and standard deviation is calculated for each band within each image. For each band, a relative gain and bias is then calculated between the IGS and USGS products, based on the mean and STDV for each of the scene subsets.

The radiometric error is expressed as a relative gain (T-RAD-GAIN) and relative bias (T-RAD-BIAS), which are computed from the differences in at-aperture radiance between the IGS product band and the corresponding USGS product band as described in Section 3.6. The error threshold represents the maximum percentage deviation between the at-satellite radiance values in the IGS product compared to the corresponding value in the USGS product.

Relative Gain <= T-RAD-GAIN
Relative Bias <= T-RAD-BIAS

The criteria for “PASS” include the following:

$$\text{Relative Gain} = | STDV_{IGS} - STDV_{USGS} | / STDV_{USGS} <= \text{T-RAD-GAIN (2\%)}$$
$$\text{Relative Bias} = | MEAN_{IGS} - (STDV_{IGS} / STDV_{USGS}) * MEAN_{USGS} | <= \text{T-RAD-BIAS}$$

Note: If a radiometric comparison falls outside the established error thresholds, the scenes will be analyzed more closely before establishing product failure. This involves using a more precise subsetting method to obtain and compare smaller, homogenous regions of interest within both the IGS and USGS scenes.

Section 4 L1G Validation Error Thresholds

The following USGS/IGS data consistency thresholds were established during the validation subgroup meeting at LTWG-11 on February 5, 2002 in Canberra, Australia.

4.1 Absolute (ABS) Geometric Error Threshold

The current error threshold for T-GEOM-ABS is:

T-GEOM-ABS = 230 m

4.2 Relative (REL) Geometric Error Threshold

The current error threshold for T-GEOM-REL is:

T-GEOM-REL = 30 m

4.3 Band-to-Band Geometric Error Threshold

The current error threshold for T-GEOM-BAND (averaged) is:

T-GEOM-BAND = 0.17 pixels

4.4 Radiometric Error Threshold

The current error thresholds for T-RAD-GAIN and T-RAD-BIAS are:

T-RAD-GAIN = 2%
T-RAD-BIAS = variable (varies by band and gain state, as shown in Table 4-1)

Band	Low Gain	High Gain
Band 1	2.36	1.55
Band 2	2.42	1.60
Band 3	1.89	1.24
Band 4	1.94	1.28
Band 5	0.38	0.25
Band 6	0.13	0.07
Band 7	0.13	0.09
Band 8	1.95	1.28
*Units are Watts / (meter^2 * steradian * µm)*		

Table 4-1. Radiometric Error Threshold

4.5 Scene Framing Error Threshold

The current error threshold for T-FRAME is:

T-FRAME = 9 km

Appendix A Pixel Referencing

Several sub-pixel location references are in use for assigning pixel ground coordinates. The selection of a pixel reference location (e.g., pixel center or pixel corner/edge) becomes particularly important when products include image bands at varying spatial resolutions. This Level 1 validation product specification does not mandate the use of a particular reference for either aligning the multi-resolution bands or for reporting the corner coordinates of the band files; but the use of a pixel center reference is preferred for both aligning the panchromatic, Visible and Near Infrared (VNIR)/ Short Wavelength Infrared (SWIR), and thermal bands, and for reporting the band file corner coordinates.

If a pixel corner reference is used, it should be applied in the manner of a neat line – that is, the corner reference should be to the outer edge of the image area. In this case, the upper left product corner would be referenced to the upper left corner of the upper left pixel, the lower right product corner would be referenced to the lower right corner of the lower right pixel, and so forth. By adhering to this convention, it will be possible to infer the combination of band alignment and corner reporting references (e.g., align centers/report centers, align edges/report edges, align edges/report centers, align centers/report edges) in use for a particular product by analyzing the corner coordinate, pixel spacing, and line/sample number information provided in the FAST-L7A header files.

As suggested above, some processing systems used a mixture of pixel corner and pixel center references. For example, the NLAPS system that the USGS uses aligns the multi-resolution bands based on the pixel corners/edges, but reports file corner coordinates based on the pixel centers. This leads to the multi-resolution bands having different reported corner coordinates. To support this, the FAST-L7A provides separate header records for each of the multi-resolution band sets. The L1G metadata file also includes optional parameters for specifying the corners of the panchromatic and thermal bands separately from the VNIR/SWIR (solar reflective) bands.

Acronyms

CC	Cubic Convolution
DFCB	Data Format Control Book
ETM+	Enhanced Thematic Mapper Plus
FL7A	Fast-L7A
FTP	File Transfer Protocol
IC	International Cooperator
IGS	International Ground Station
LGSOWG	Landsat Ground Station Operations Working Group
LTWG	Landsat Technical Working Group
L1G	Level 1G
L7	Landsat 7
L0Rp	Level Zero Reformatted Distribution Product
LPGS	Level 1 Product Generation System
MOU	Memorandum of Understanding
NLAPS	National Land Archive Processing System
NN	Nearest Neighbor
POC	Point-Of-Contact
RCC	Raw Computer Compatible
RMSE	Root mean square error
STDV	Standard Deviation
UTM	Universal Transverse Mercator
WGS84	World Geodetic System of 1984
WRS-2	Worldwide Reference System-2

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Memorandum of Understanding Between the U.S. Geological Survey of the Department of the Interior and the International Cooperator for the Direct Reception and Distribution of Landsat 7 Data, and the Annex III for Data Exchange.